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FINAL REPORT

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This report represents the authors' views, which in general are in harmony with technical criteria of the Office of Civil Defense. However, a preliminary evaluation by OCD indicates that further study of the subject is desirable.

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CRASH CIVIL DEFENSE PROGRAM STUDY

by

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ABSTRACT

A crash civil defense program is one which is implemented one to fourteen days prior to attack. It is initiated because of a political or military crisis. This study identifies and analyzes several measures that can be effective in this time period in dispersing and protecting population and resources. The problems associated with constructing a crash plan prior to implementation are identified, and some principles for crash planning are given. The major conclusion is that crash planning can significantly improve existing civil defense capabilities. Several actions are recommended which would lead to operational crash planning.

CRASH CIVIL DEFENSE PROGRAM STUDY

Contents

SUMMARY

A thermonuclear attack on the United States may be preceded by a period of intense crisis. In this study we investigate the actions that could be taken by federal, state and local authorities within a one to fourteen day "crash" period to alleviate the effects of an attack. Several crash measures have been identified and analyzed and the principles of crash civil defense planning have been developed. (In this study, "crash plan" means a plan which is implemented within the short crash period; the actual planning is to be conducted well in advance of implementation.)

A civil defense plan which assumes strategic warning must differ in several respects from a plan which assumes only tactical warning. When analyzing alternative crash plans one must consider such parameters as geographic area, climatic conditions, intensity of the crisis and the kind of attack expected. A decision concerning activities to be initiated during an intense crisis must be made; the spectrum of alternatives includes a decision to do nothing.

While significant population dispersal is not feasible if only tactical warning is received, it becomes an important element of crash planning for probable targets. Under many contingencies it would be a major element of crash strategy. Several studies of strategic evacuation are under way or completed; we shall depend on these results when incorporating evacuation into crash planning. Previous studies have concluded that 90% evacuation of metropolitan areas can be accomplished within less than one week.

Intimately connected with dispersal strategy is the problem of improvising fallout shelter for the population. Much can be done during the crash period to complement existing shelter programs. The problem of providing shelter for

evacuees can be solved in most cases. Several specific recommendations for crash shelter programs are given. Under a typical attack, it is estimated that a one week crash shelter program alone could reduce casualties by at least thirty million.

It is also possible to protect some resources against direct weapons effects during the crash period. We have examined the feasibility and effectiveness of some thermal countermeasures and found that under certain circumstances they yield sufficient payoff to be incorporated into crash plans. Industrial hardening, evacuation and repositioning are feasible in many cases, but these measures are not to be implemented indiscriminately since they require extensive manpower. Detailed studies of critical industries are necessary to identify costs and benefits of these measures.

Since many of the effective crash measures require mobilization of large blocks of manpower, a special public information program to initiate and execute this mobilization will be an essential part of crash planning. Specific recommendations for the optimum use of available resources by federal, state and local agencies are given.

In most cases crash measures are competitive with one another for manpower and resources. The problem of constructing an optimum crash plan is examined. A generally desirable strategy for a probable target area would be to implement a shelter improvisation program outside the area and then evacuate at a rate at least sufficient to fill the shelters. As the probability that an area will be targeted goes down, heavier emphasis should be placed on shelter improvement and stocking within the area, using any remaining time to protect and stock resources valuable for recovery.

Civil defense capabilities can, at any time in the immediate future, be significantly increased by the incorporation of crash plans into the existing plans at all levels. Planning costs would be low compared to other programs of equal effectiveness. On the other hand, dollar costs of implementation (if the attack did not occur) might be higher than long-range programs of comparable effectiveness. While a crash plan cannot replace long-range plans, it can complement them in many ways.

It is recommended that studies which will lead to operational crash planning be continued. The most valuable effort at this time would be the writing of specific crash plans for several geographic areas. This would allow a realistic application of the principles developed in this study and disclose the major problem areas that would be encountered in more extensive planning. It would also allow a concrete assessment of the improvement effected in survival capabilities. It is also recommended that a federal crash public information contingency plan, as discussed in Chapter 5, be developed. It would not be premature for O.C.D. to prepare and distribute a document introducing the concept of crash planning at this time.

Several areas of further research which would aid operational planning are pointed out as they arise.

Chapter 1

INTRODUCTION

Scope of Work

The contract under which this study was completed provided for developing data to facilitate making plans for "crash" civil defense programs that can be implemented rapidly in brief preattack time periods. Specifically, the study was to:

1. Assume several differing possible attack situations over varying periods of time ranging from one day to two weeks.
2. Determine requirements for rapid civilian deployment and protection of population, facilities, equipment and supplies for several closely related major civil defense systems and programs (e.g., shelter and training).
3. Draw upon data previously developed.
4. Suggest feasible, expedient ways and means of using resources at hand (facilities, equipment, supplies, and personnel) to achieve emergency protection.
5. Estimate the extent and degree of organization and protection that could be achieved by alternate means over specific periods of time.
6. Determine the ways, means and programs that offer optimal feasibility on a time and cost-effectiveness basis.
7. Provide findings in a form suitable for operational application.

Nature of Crash CD

Most past civil defense planning has been directed toward activities which could be completed within a few hours or less, and long-range programs for providing shelters and stockpiles of resources. It has been increasingly recognized that there will most likely not be a sudden transition from a cold to a hot war, but rather a period of increasing tension leading up to an attack on U. S. population centers. Such a range of crisis situations has been termed an "escalation ladder" (Reference 1).

At the top of the escalation ladder such situations as limited nuclear attack on populations or counterforce attacks occur. Such serious crises could immediately precede an all-out population attack, and hence require what is termed "desperate" measures. Such measures would include mass evacuation and search for shelter, with little regard for damage or the endangering of lives.

At lower levels of tension, when an attack would not appear to be so imminent, crash civil defense measures might be initiated. Such activities will be undertaken with a sense of urgency, yet on the assumption that some time remains to accomplish them. In Appendix A, several scenarios of possible crisis-tension buildup situations are outlined. These scenarios are examples of situations in which a crash civil defense program would be initiated if it were available to the decision maker.

It should be noted that crash measures will not usually be just the acceleration of current civil defense programs, but the initiation of actions that can be accomplished in a short period of time and at least temporarily effect a significant increase in survivability.

<u>Feasible Crash Activities</u>

In crash civil defense, as in long-term civil defense activities, measures to increase the probability of national survival can be categorized as follows:

1. Dispersal (including evacuation) of people
2. Dispersal of resources

3. Protection of people

4. Protection of resources.

These categories are not independent of each other. For example, evacuation or dispersal measures will probably be accompanied by some provisions for protection in the reception areas, and by some dispersal of resources necessary to support the evacuees. An initial phase of the study identified a large number of specific crash measures. Then, several of the more promising measures were analyzed individually for their effectiveness in accomplishing the specific task for which they are designed. Chapters 2, 3 and 4 are concerned with these specific measures. Several measures which were identified but not established as feasible were excluded from this final report. Several of these, such as mass immunization, are deserving of further study.

Information dissemination for a crash program is an essential activity which influences the success of most of these measures. This problem is discussed in Chapter 5.

Finally, in the last two chapters, we shall discuss the problem of developing a strategy which is composed of the optimum mix of these various measures, taking into account the entire crash environment. Crash planning as a whole will then be discussed, without regard to the specific measures relied upon for implementation.

<u>Crash Planning</u>

If crash planning is to be successful, it becomes apparent early in the study that a combined federal, regional, state and local effort must be exerted. The federal government must take the initial steps to introduce the concept that strategic warning can trigger crash measures that will increase survivability. Next, since local and state levels of government have inadequate capabilities and resources, the federal agencies must continue their leadership in development, research, identification, and implementation of crash planning concepts and measures. Finally, there are many elements of a crash information dissemination program that the federal agencies are best equipped to handle, as we will see in Chapter 5. Inevitably, a large burden of crash planning must necessarily fall on the local planner, since crash plans must be written specifically for the area under consideration if they are to be effective.

A crash plan is in effect a contingency plan, held in abeyance until a top level decision maker decides to initiate the plan. In this respect, it is different from long-range civil defense planning. A planner must consider this decision problem when writing the plan. In general, the higher the cost of the plan in dollars, the more reluctant the decision maker will be to implement it, since he can never be certain the attack will occur. While we will discuss these problems superficially, and in some cases estimate dollar costs of implementation in the analysis, we have not had time to consider in this study the decision problem of implementing crash plans. Neither have we considered the effect implementation would have on possible attackers.

Important Parameters in the Analysis

Finally, we will mention in this introduction several of the parameters which must be considered when analyzing the effectiveness of a particular measure or an entire crash plan. These parameters are:

1. Geographic area of applicability
2. Seasonal or climatic limitations
3. Costs of implementation to a non-attacked economy
4. Effectiveness in saving lives and property
5. Time required for implementation
6. Preplanning required

7. Extent of population mobilization required for implementation

8. Probability the attack will occur

9. Estimated time remaining before attack

10. Effects of implementation on potential attackers

11. Intensity and nature of attack expected

12. State of public motivation and morale.

In analyzing the specific crash measures, we will attempt to examine primary effectiveness parameters and the major limitations of the measure. When crash planning as a whole is considered, we shall derive some general principles which can guide the crash planner; however, this problem is so complex that one cannot expect to formulate a universally valid optimum strategy for a complete plan.

Chapter 2

POPULATION AND RESOURCE DISPERSAL

Complexity of the Evacuation Problem

The only practical method of alleviating direct nuclear weapons effects is to get out of the way. Since the one-fourteen day crash period provides sufficient time to evacuate probable target areas, population dispersal becomes an attractive element of crash planning.

The consideration of evacuation under any circumstances related to nuclear warfare is complicated. Evacuation obviously reduces the immediate effects of large scale attacks upon cities; but the dispersed population cannot be considered as escaping with no loss. The effects of fallout and the effects of the evacuation itself on health, food supplies, shelter, and other conditions must be taken into account. As we consider a decreasing scale of attacks upon cities, then the latter considerations eventually outweigh any advantages of evacuation.

Current Studies Pertaining to Evacuation

Reference (1) considers some general aspects of evacuation, including the possible effects on the actions of the opponent in periods of tension, and the specific problem of evacuation in the northeastern part of the United States. Transportation capabilities are shown to make possible the evacuation of about three-fourths of the population of cities to remote areas in two days, and the evacuation of ninety per cent of those in all densely populated areas in less than a week. The problem of vulnerability and shelter against fallout in the reception areas is also analyzed.

A study being conducted by Human Sciences Research, Inc. considers some of the social aspects of evacuation. Included in the considerations is the effect of staged evacuation, where evacuees from cities are processed at some intermediate point before being further dispersed into reception areas.

Other studies relating to evacuation are being conducted by the Academy for Interscience Methodology and the Dikewood Corporation. The former, has the problem of developing a simulation model which takes into account the major parameters affecting the successful accomplishment of a tactical evacuation. The latter group is understood to be conducting a study relating to dispersal of supplies.

In addition to these studies, such a program as Jumbo (NREC damage assessment program) provides indications of the effectiveness of evacuation and dispersal under varying attack conditions and population distributions.

The results of these studies, when completed, and other studies can be included in planning for crash measures.

Type of Evacuation Measures Available for Crash Civil Defense

It is apparent that with the assumption of a time span of one to fourteen days for crash civil defense activities, a considerable number of variations of evacuation and dispersal measures becomes possible. These measures may vary in magnitude, areas to be evacuated, the urgency of evacuation, the reception areas, and the degree of control. Table 1 contains a partial list of general types of evacuation possible.

Each of these types of evacuation has its particular merits and drawbacks, and in crash civil defense the choice must not necessarily be confined to a single type. Thus, there may be a hasty evacuation of a limited number to contiguous areas, followed by a more orderly type of evacuation as time passes. However, the decision maker must have the means to review the requirements for whatever type of evacuation plan he chooses to follow.

Table 1

TYPES OF EVACUATION FROM CITIES

Numbers Involved	Speed of Evacuation	Intermediate Staging	Reception Areas
all	hasty	none	remote
all	hasty	none	contiguous
all	gradual	none	remote
part	hasty	none	remote
part	gradual	yes	remote
part	gradual	none	contiguous

remote area: >50 miles.

contiguous area: 10 - 50 miles.

Requirements for Implementing Evacuation Measures

Preparation for and the conduct of evacuation and dispersal of people call for plans that will permit the best use of the time available. The very fact that time and a variety of measures are available could result at least in disorder, waste of valuable resources, and a loss of confidence in civil defense leadership, instead of more efficiently conducted operations.

Plans need to cover the different phases of evacuation, the resources necessary for support, and the responsibilities of national, regional, state and local decision makers.

Evacuation can reasonably be divided into three phases: the preparation phase, the en route phase, and the shelter phase. However, there may be differences in planning depending upon whether the evacuation is to a remote area or to a nearby (contiguous) area.

Resources needed for support can also be categorized. Four general types are important:

Transportation - including vehicles, fuel, route maintenance and traffic control

Shelter - against both fallout and natural environment

Sustenance - including food, water, heat and clothing

Medical - both preventive and remedial.

For long periods of evacuation, other types of support may become important. Education and recreation for the young have been suggested as other functions for which resources must be provided.

It is evident that coordinated planning is necessary in many aspects of a crash evacuation program. For example, local authorities may be responsible for the planning of transportation before and during the early en route phase; state authorities for the en route and dispersal phases in evacuation to contiguous areas; regional authorities for the en route and dispersal phases in remote areas; and national authorities for some types of transportation (e.g., aircraft for essential personnel such as medical teams) during the dispersal phase. Table 2 shows a possible over-all distribution of responsibilities.

Table 2

DELEGATION OF EVACUATION RESPONSIBILITIES

Evacuation to Contiguous Area	Transportation	Shelter	Sustenance	Medical
Preparation	L	S,L	S,L	S,L
En Route	S,L	S,L	S	S
Dispersal	S	S,L	R,S	S
Evacuation to Remote Area				
Preparation	S,L	R,S	R,S	S,L
En Route	R,S	R,S	N,R	S
Dispersal	N,R,S	N,R	N,R,S	R,S

(N is for national, R for regional, S for state, and L for local.)

Some Possible Crash Measures in Dispersal of People

Some possible activities that appear feasible in a crash civil defense situation and will contribute to the effectiveness of dispersal of people are as follows:

1. Establishment of staging points outside the immediate metropolitan area. At the staging point, supplies could be checked and ration cards (if used) issued, medical examinations and immunization performed, assignments made to ultimate reception areas, and records kept that would assist in locating evacuees.
2. Establishment of an evacuation control system, including traffic control points, air observers, and communication procedures.
3. Location, preparation, and assignment of vehicles for private conveyances. This would include buses, trucks, railway equipment and possibly new and used cars on dealers' lots.
4. Prepositioning equipment along proposed evacuation routes to remove bottlenecks. Wreckers can remove cars and bulldozers can clear paths around major obstructions. Large helicopters might also be readied in order to remove blocks that could not be reached readily by ground equipment, (for example, on bridges.)
5. Establish procedures for supplies of gasoline along evacuation routes.

Reference (1) deals with some of the above measures in detail for the Northeastern United States.

Types of Resources to be Dispersed

As in the case of dispersal of people, dispersal of resources reduces vulnerability but requires planning to be effective.

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Resources can be dispersed for two general purposes: to support the population in the en route and shelter phases, and to increase the rate of recovery after an attack.

The types of resources that might be evacuated to provide support for evacuees are numerous, and planning must include priorities (depending on area, season, etc.).

High on the list of priorities would be the following types of resources that are available for stocking shelters:

food and water (care to avoid fallout contamination)
blankets and clothing
plastic bags
radios
radiation detectors
medical supplies
decontamination equipment

However, in a crash civil defense period, items useful for constructing or improving shelters or for providing mobility in reception areas up to the time of tactical warning should also be included in dispersal plans. These items might include

sand or cement
burlap bags
excavating equipment
bulldozers
gasoline
generators
tools, including power tools

The dispersal of the above types of equipment could make a significant improvement in the provision of shelter, since more efficient use of the manpower would be permitted. For example, a bulldozer and a pile of sandbags would be of considerable use to a group of people trying to improve the protection factor of homes in a given area.

If the evacuation of such items seems unreasonable, it should be remembered that days may elapse after evacuation until the attack comes or the evacuation is ended. Regardless of which occurs first, food processed during the previous period would extend the supply of food as well as providing variety. In addition, food processing equipment, building materials, and rolling stock, if saved by means of dispersal, can contribute to the restoration of the economy.

However, much of the industrial equipment concentrated in population centers will be impossible to move in the time available for crash civil defense. Measures for protecting these resources will be discussed in Chapter 4.

Conclusion

The time available for crash civil defense measures will often permit not only systematic evacuation and dispersal of people, but of resources for support in the reception areas and later recovery. The list of possible items is large, and priorities for evacuation must be assigned depending upon potential usefulness.

If a decision is made to evacuate populations, it implies associated decisions for minimum resource dispersal, and shelter improvisation.

Chapter 3

IMPROVEMENT AND IMPROVISATION OF SHELTER

Need for Additional Shelter

In most cases, an important element of crash planning will be to increase the number of available shelter spaces. There are relatively few instances in which an area has adequate fallout shelter for its population, even assuming population dispersal is not attempted. If dispersal is attempted, then in most cases the existing shelter spaces are being left behind, and new shelter space for most of the evacuated population must be provided. (In Appendix E, shelter spaces for major metropolitan areas are given.) In this chapter we will examine how adequate shelter can be provided in the crash period by both improving the protection factor of existing structures and improvising shelter. While it is apparent that the total crash strategy in high probability target areas will involve a mixture of dispersal and shelter improvisation, in this chapter we will consider only the sheltering measures. The crash planner must decide upon the optimum strategy for his particular area, using the principles of Chapter 7 to evaluate the environment.

Improving Existing Shelter

If existing buildings are available which offer some fallout protection, then in many cases the protection factor can be raised to at least one hundred by increasing the mass around the basic core that is suitable for shelter. The materials that are usable for this purpose will depend upon the particular location of the structure. Earth and water are nearly always available. Dense materials in the building could be used, although in this case it is impossible to give recommendations which are universally applicable because of the variety of circumstances.

The problem of improving the PF of a single residential unit is largely dependent on whether a basement is present, and also on the construction materials used.

In a crash public information program, specific instructions for improving residential units should be included for the type of structures most likely to be found in the area; i.e. basements may or may not be prevalent.

Improving public buildings or apartments is generally more difficult to effect. First, the shelter core must be selected, and then barriers must be improvised which do not exceed the structural strength of the building. The great variety of suitable buildings makes this a complex problem. Reference(16) considers in some detail the problem of hasty improvement of existing shelters. In general it is most feasible to improve areas that are at least partially below grade. The principles involved in the computation of protection factors are sufficiently well known for a crash planner to make a reasonable estimate of the improvements which can be effected with the public buildings in his area.* The services of an architect or engineer are of value here since one must be careful not to exceed the floor loadings that can be tolerated when improvising mass barriers. Since data are available from the National Fallout Shelter Survey on many lower PF category shelters, a natural first step in a crash shelter improvement program would be to devise specific plans for the improvement of these shelters. After the evacuation strategy has been rejected for a particular area, the next step in the crash plans should be the writing of a specific set of instructions for the improvement of protection factors of existing structures with the materials which will be at hand.

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* Modified FOSDIC forms including the improvised barrier thicknesses could be submitted by local and state CD officials for PF computation using the present computer programs.

Stocking and Marking

One must also consider the stocking of shelters as well as their improvement and improvisation. Here again, the specific plan must depend strongly upon the resources available. Wholesale and retail food stocks which can be stored should be provided for the shelters, and more important, water should be stored as rapidly as the shelters are improvised. Care must be taken to avoid radioactive contamination of stocks.

After shelters have been improvised, in urban areas (no evacuation case) it is essential that the population be able to find and enter the shelter quickly once tactical warning is received. Many crash expedients would be useful in accomplishing this essential task. If dispersal has not been effected, then shelter entry drills would be valuable. An essential measure is the immediate marking of all shelters, improvised or existing, if this has not already been accomplished. To this end, existing or improvised signs could be attached or painted directly on walls.

Another important element of the crash plan will be assignment of the population to the available shelters. This decision should be made during the planning phase so an optimum distribution can be effected upon implementation of the crash plans. An effective technique of implementation would be to paint large, colorful arrows on streets and sidewalks during the crash period so any given individual, upon emerging from his residence or place of work, can follow a set of arrows to the proper shelter upon receipt of tactical warning. It might be desirable to have two colors of arrows, one for daytime and one for nighttime population distributions. If the templates and paint were stored in advance, the cost would be low and the time for implementation would be reduced. At any rate multiple maps should be provided with the crash plans which show precisely where the arrows are to be drawn upon implementation.

Ventilation

The effectiveness of shelters can be significantly improved if forced ventilation can be provided. It may prove possible to improvise effective air pumps in many cases. Phase 2 of the Shelter Survey is gathering data on ventilation. If high capacity fans are available from the heating or air conditioning equipment, then drawings could be prepared for coupling internal combustion engines, electric motors or other "manpower" power sources. This type of crash planning would be more technical and involved, would require the services of engineers to draw the contingency plans and would probably involve the enlisting of mechanics on a stand-by basis. Of course, it is not desirable for a crash plan to depend upon such stand-by personnel, but the great improvement in capacity of shelter would, especially if shelters were inadequate, justify a considerable effort on the part of the crash planner. Reference (1) describes more easily improvised air pumps which should be considered.

At the present state of crash planning research, it would be desirable to take some buildings with low protection factors and actually implement specific plans for emergency improvement, stocking and ventilating. While each building will undoubtedly present special complications, it is felt that a great deal would be learned about the problems that would be encountered by pilot improvisations and demonstrations.

Improvisation of Shelter

If no existing structures are available for improvement, either because of evacuation or because sufficient buildings do not exist in the area of interest, then the shelter must be improvised from basic raw materials. For such an area and within the time constraints, the most practical method of improvisation will be the digging of trenches and fox holes. On the smallest scale, and in many of the more heavily populated areas, an individual family unit can dig a fox hole large enough for survival with hand tools within a few hours if weather permits. References 1 and 2 discuss the time requirements for hand digging of trenches. In general, a few hours is adequate to improvise a one hundred PF or better austere shelter for one family. Effort becomes more efficient in multifamily units. A major obstacle to such shelter improvisation would be frozen ground. In these circumstances, power equipment would be required for trench or foxhole digging. On a larger and more effective scale, earth moving equipment in the area can be mustered to dig long trenches. Many pieces of such equipment surround major metropolitan areas. An initial, low cost measure which could be taken at a low crisis level would be the dispersal of equipment to the shelter improvisation sites.

It will be essential that some technical principles of shelter improvisation be adhered to if these trenches are to be effective. While in the following we will be primarily concerned with trenches as a fallout shelter, it should be pointed out that they are also effective against direct weapons effects. A properly constructed trench offers protection against thermal and prompt radiation of nearly any magnitude that would be associated with blast phenomena that could be survived. For example, at three miles from a five megaton low air burst, personnel have a fifty per cent chance of survival if in a foxhole. They must be eighteen miles away if in the open for the same chance.

<u>The Trench Shelter</u>

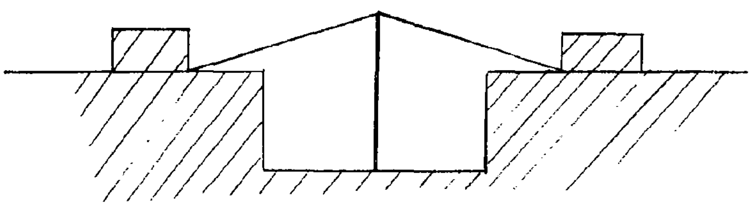
In Appendix B, the parameters which affect the protection factor of a trench shelter are studied in detail. A summary of these results and the recommendations are presented here.

While a basic trench offers some protection against fallout, the addition of a cover greatly improves the PF. A dense material cover is most desirable if it is adequately constructed. If it must project above the plane of contamination, care must be exercised to see that the cover extends well beyond the lips of the trench. A simple cover that is transparent to gamma radiation and can be made from plastic, a tent or painted sheets and blankets offers higher PF's than no cover, especially if the fallout can be shaken off.

The inadvertent construction of a ridge next to the lip and extending above the contaminated plane can dangerously scatter radiation into the trench. Hence, care must be exercised to make a ridge with the displaced earth low and wide and keep it several feet away from the lip of the trench. In all cases, it is essential to choose the highest elevations available for trench construction. These sites should be carefully chosen, with the help of surveyors, by the crash planner while he is writing the plan for an area. Height of the water table, drainage properties, and soil conditions should also be taken into account.

If a foxhole is dug by hand, the overhead aperture-area to depth ratio should be kept as small as practically possible. If a trench is dug, the width should be kept as small as practical. Of course, deepening a given trench always increases its PF.

Figure 1 is a summary of the trench or foxhole shelter recommendations.



A QUICKLY IMPROVISED TRENCH FALLOUT SHELTER

Figure 1

In most areas, either rural or urban, there will be sufficient earth moving equipment available to dig trenches at a rate adequate to shelter the population within a few days. A local crash planner should identify equipment in his area, and inform their owners of its possible use in a national emergency. It is possible that a licensing program similar to that used for shelter stocking and marking would prove helpful, with each piece of equipment having an assigned task if the crash plan is implemented.

There is available an estimated 100,000 pieces of earth moving equipment in the United States. If an average capability of fifty cubic yards/hour is assumed, then approximately 6.5 million shelter spaces (500 cubic feet per person) of trench can be constructed each 24 hour period. A 6 feet deep by 9 feet wide trench properly constructed with decontaminated cover is approximately a 30 PF shelter.

Individual Fallout Shields

The above techniques for improving and improvising shelter require from several hours to several days. In many cases, even with adequate strategic warning, individuals will be caught in a fallout field with inadequate shelter, that is, the protection factor will be so low that a dangerous dose of radiation will be received even though the fallout particles will be kept away from their person. In such cases, an expedient that can be implemented within a few minutes and within a shelter is desirable. Such an expedient is the individual dense material shield. Again, the precise nature of the improvised shield can vary widely depending upon the materials available. In its simplest form it could consist of earth piled over the torso in a trench shelter. More elaborate and comfortable shields could be improvised from materials available in a common household. For example, an interior door could be supported with books, and then any dense materials available could be piled on top to provide several hundred pounds per square foot of shielding.

The two phenomena which make such a shield highly effective for the effort involved are the following: First, a large fraction of the total dose is received within the first few hours after the fallout arrives. Second, there is strong experimental and theoretical evidence that the shielding of the abdominal region alone approaches in effectiveness whole body shielding in preventing the pathological effects of large doses of radiation. These facts imply that a dense shield which protects the midsection of the body and which is occupied for the first eight to thirty-six hours (later to sleep in) can readily allow an individual to survive in a fallout field ten times as intense as he could otherwise survive in with any given exterior shelter configuration. Such a shield is readily improvised from common household materials, and it is generally the family caught at home that has the marginal or inadequate protection. Such shields are impractical in large public shelters where space is at a premium and no materials are available. The effectiveness of such a shield is analyzed in detail in Appendix C.

Effectiveness

A typical RISK II damage assessment program output was used to estimate the number of survivors that could be added if the protection factor available throughout the U. S. were raised from 10 to 30. On the basis of Appendix B, it is conservatively estimated that the entire population can be provided a 30 or greater PF shelter within one week. A typical attack with 10 PF shelters shows 70.3 million casualties of which 45.3 million were fatalities. With 30 PF shelters, these numbers were crudely estimated to be 36.5 million casualties with 18 million fatalities. Hence it is roughly estimated that a one week crash shelter program alone would save approximately 34 million casualties and 26 million fatalities.

Conclusions

In most cases a few days of crash activity will allow sufficient improvisation and improvement of shelter to accommodate the entire population. If evacuation is a part of the strategy, leaving most existing shelter behind, the task of providing shelter is more difficult, but at least an austere shelter of 30 PF or greater could be provided for the entire population within one week unless the weather were severe.

Chapter 4

PROTECTION OF RESOURCES

While the primary emphasis in a crash plan will be on the saving of human life, and preserving the resources required to sustain life in the immediate pre- and postattack period, if time or circumstances permit, the crash effort should be extended to save industrial and other resources valuable for long term recovery efforts.

Industrial Resources

An industrial program to evacuate vital parts highly susceptible to blast could in many cases be part of an industrial crash plan. Without evacuation, there is relatively little one can do to protect resources against direct blast effects. We have not studied this problem in detail but it is apparent that in special circumstances a crash plan could include expedients which would harden certain types of resources. For example, if a large industrial complex was basically very hard (heavy machine tools, etc.) but depended heavily upon a few soft components (electronics, gauges, etc.) a crash plan could include the disassembly, crating and burying (or evacuation) of these vital components to aid the postattack recovery. The specific program best suited to an industry or an area should be worked out by cooperation between the crash planner and industrial leaders. The problem of blast protection of resources is specialized to the resource considered and study constraints have prevented detailed analysis of specific industrial countermeasures. It should be pointed out, though, that these measures may require manpower that would be used in more direct personal survival measures.

Fires

Fire is a direct weapon effect which can easily become more destructive than blast, but fortunately it is not so difficult to cope with. Fire can be created by either indirect blast effects or direct thermal radiation.

Since a major source of induced fires would be disrupted gas mains and downed power lines, a crash plan should provide for shutting off these at the distribution source if possible, provided that the area is a likely target. This is desirable if a city is to be evacuated. The remaining types of blast induced fires would be caused primarily by stored hydrocarbon fuels, and little can be done in a short time period to remove these sources.

Direct Thermal Countermeasures

The intense thermal radiation from a high yield air burst can extend well beyond the blast damage area. Further, a few simple expedients will in many cases substantially reduce the danger of an ignition from these effects. The effectiveness of thermal countermeasures is studied in Appendix D. We will outline the results obtained there.

The particular thermal countermeasures considered include cleaning up flammable rubbish, removing cloth awnings, removing curtains and other flammables exposed through windows, painting windows or covering them with aluminum foil, etc. Small ignitions can spread into large mass fires without immediate attention, and hence, would result in great property loss and many casualties. Also, if buildings burned had shelter spaces in the basements, the burning rubble would be a severe danger to the shelterees (Reference 3).

There are essentially no climatic or seasonal limitations to implementing these measures. Some conditions, such as heavy rain, snow or fog alleviate the problem considerably and make implementation less imperative. In fact, the hazard of thermal ignition could be reduced if heavy snow were present by piling the snow against the windows. At times when interiors are heated, however, humidity is quite low and interior ignitions become more likely.

Since the range of thermal effects from a high yield air burst is often significantly greater than the range of blast damage, it is reasonable to expect high payoffs from protecting against these thermal effects. Further, it is considerably easier to protect people and property against thermal effects than against blast effects. These facts imply that a crash plan might profitably devote part of the preparation time to such thermal countermeasures.

Thermal countermeasures are clearly inappropriate in extremely low population density areas which have a low probability of being targets. They are appropriate for high population density areas to the extent that it is believed a countervalue attack is imminent, i.e., that these areas will be targeted.

After the household has received instructions, either printed or oral, and has decided to implement the thermal countermeasures, it is estimated that a typical dwelling unit with auto could be prepared to withstand 25 cal/cm^2 from a multi-megaton weapon within one to three hours. This should allow for removing ignitable rubbish from the yard, painting, whitewashing, or covering windows, removing curtains and other thin flammables within the windows, and wetting upholstered furniture and flammables which might be exposed.

In the absence of countermeasures, thin flammable household goods ignite at around 10 cal/cm^2 and multiple fires can be expected in the 15 cal/cm^2 area.

On the basis of the work in Appendix D, it appears that the suburban areas provide high payoffs for implementation of the thermal countermeasures. Since a few ignitions in the high building density area will burn large areas, little could be done to save them unless effective fire fighting were possible after the explosion. One payoff even then would be to increase the time required for fire to reach a given area, hence giving the populace time to escape or prepare for it. If preattack evacuation of these areas is attempted, then there is little reason to prepare them for thermal effects anyway, especially if the preparations are likely to be ineffective. In summary, the measures discussed are most desirable in the low density suburban areas, which in many cities correspond to the "high payoff ring" (described in Appendix D) for high yield weapons.

Conclusions

IF:
1. The area under consideration is within fifty miles of a possible GZ and is not being evacuated
2. Emergency stocks of water and food have been provided
3. Some measure of fallout protection has been provided
4. Building density is "low"

THEN:
1. Thoroughly clean up rubbish or other flammables outside dwelling
2. Paint, whitewash or cover with aluminum foil windows of dwellings and automobiles
3. Remove drapes, pile in corner with other flammables and wet down exposed upholstered furniture.

Chapter 5

INFORMATION DISSEMINATION FOR A CRASH CIVIL DEFENSE PLAN

Role of Public Information

We have been concerned primarily with analysis of the most profitable measures in the crash period. In many cases, those preparations which can be completed in this short time period must be performed by the general population; the special government agencies such as police, fire and civil defense offices cannot conduct large scale operations in these short time periods even without financial and legal constraints. Hence, the success of a crash mobilization depends heavily upon motivating and informing the public of the actions that are appropriate. This chapter is concerned with the problem of information dissemination and public motivation.

Within the time constraints imposed by the crash period, it is apparent that any information dissemination device used must be effective within a few hours. Further, two distinct goals must be accomplished:

1. Individuals must be motivated to act;
2. Information for intelligent action must be presented effectively.

It is assumed in this study that the first goal, normally the most difficult to achieve, is accomplished largely by the crisis circumstance. A Presidential decree that a crisis exists, coupled with announcements by state and local officials, is assumed to provide sufficient motivation when it is associated with the high density of civil defense information that would be distributed for a crash plan. It must be pointed out, however, that this motivation assumption is as yet unproven, and experienced opinion varies widely as to its validity.

The second goal must be accomplished in two separate steps. First, a certain level of knowledge concerning weapons effects and fallout must be imparted to the public. Second, specific instructions for the particular area involved must be disseminated and acted upon.

Level of Public Knowledge

At present there have been only limited samples taken to determine the level of public knowledge concerning nuclear warfare. One such survey, (Reference 6), taken in a metropolitan area, is summarized in Table 3.

Table 3

UNDERSTANDING OF FALLOUT FROM A RANDOM SAMPLE OF AUSTIN, TEXAS CITIZENS

	No.
No answer	20
Radioactive material in air (dust particles)	120
Vague implication of contamination..aftermath of bomb (no radioactivity mentioned)	48
Poisonous gas....smell it	12
Vague implication of harm	25
Brings disease	1
Large pieces of debris in air as a result of bomb (wood, bricks, etc.)	7
Rays that harm (vague)	3
Something that gets in body and on clothes	4
Don't know	44
Too vague to be classed	16
Total	300

If this sample were taken to be representative of the population concerned, then it is clear that at least part of the time must be spent during a crash public information program to present the basic facts concerning fallout. On the other hand, if a particular area were either more or less well informed than this sample indicates, the fraction of time spent for general education should be adjusted accordingly.

Resources for Public Information Programs

The United States has huge resources for the distribution of written and spoken information. It will be essential that all of these be used as effectively as possible to accomplish the tasks required for the successful implementation of a crash civil defense program. Table 4, taken from the Statistical Abstracts of the U. S., 1962, summarizes the resources available for this purpose.

Table 4

INFORMATION DISSEMINATION RESOURCES IN THE UNITED STATES

Newspaper circulation/family in 1961	1.11 daily, .90 Sunday
Average pages in daily (circulation greater than 100,000)	43 pages
Average pages in Sunday (circulation greater than 100,000)	139 pages
Weekly newspaper circulation	29.8 million
Total AM-FM or AM stations in 1960	3,470
Total TV stations	530
Population with TV, metropolitan	92 %
Population with TV, rural	85 %
Population with radios	97 %
Weekly periodicals (478 publishers)	105 million

The time constraints imposed on a crash plan would require that any information must be distributed to the audience within a short period after the plan is initiated. As can be seen from Table 4, the existing newspapers, radio and TV stations alone have sufficient coverage to accomplish this if they are properly used.

The reaction time of the various news media will depend strongly upon whether taped programs or newspaper plates are positioned in advance. In general, it is expected that both the quality of the programming and the reaction time would be considerably improved if such prepositioning were performed.

While prepositioning materials for public information reduces reaction time considerably, there are certain associated problems which must be considered. First, if flexibility of planning is to be maintained so the reaction can be appropriate to the crisis, it is possible that several sets of plates and tapes should be made available for various plans. While this introduces some complication, it is not felt to be serious. Also, some feel that the possibility of unauthorized use of these materials could present a hazard; however, since the probability of simultaneous misuse by several agencies at once is quite low, and even then the effect of such misuse questionable, this hazard seems quite tolerable in light of the potential benefits to be derived.

The costs involved are negligible, and hence the decision to accept crash contingency planning would imply a decision to preposition plates and tapes for newspapers, radio and TV.

Use of Resources

The general technical information to be included in the planned dissemination is of such a nature that it can be effectively handled on a national basis. Hence, it is this kind of technical information that would be most effectively given on the national TV networks, and on federally distributed newspaper plates. This information is the same for all geographic areas, hence a multiplicity of tapes and plates is not needed. For example, the Office of Civil Defense Staff College could tie into a nationwide TV network from Battle Creek, Michigan within one hour after notice. The trained instructors could provide an extemporaneous program of general information at the level discussed above.

Newspapers, while having a somewhat slower reaction time than radio and TV, are less subject to misinterpretation, can be retained for ready reference when needed, and are more effective in teaching technical details. Hence, they would be used most effectively to instruct in shelter implementation, protection expedients against direct effects, evacuation procedures and instructions, etc. Further, since radio and TV could disseminate general information in the first few hours of the crash program, the slower reacting newspapers would then phase in with specific instructions after radio and TV have made their impact.

The Baltimore Sun publishers were interviewed to obtain information representative of large metropolitan newspapers. (Baltimore is the sixth largest metropolitan area in the U. S.) It was found that if the plates are prepared in advance and a normal work crew is available it would require 30-45 minutes to set up the presses and begin the run. A modern "double delivery" press can produce 70,000 copies an hour. Depending on the number of presses running, 300,000 eight page copies can be ready for delivery in two to four hours. In Baltimore, these papers would be dropped off for delivery in all outlying districts in another hour. Home delivery time would depend upon carrier availability, but papers could be available in all areas within four hours after work was begun on the edition.

In general, these activities would not compete with other civil defense activities which might be undertaken. First, it would be one of the initial measures carried out, and hence no heavy conflict with other demands for manpower and equipment would be met. Second, the only equipment required to publish and disseminate newspapers which could be used elsewhere would be delivery trucks. Considering the small number required and the importance of the function, these trucks should have top priority to carry out their distribution function.

There are times when no production crew is on hand in newspaper printing shops. This time could range from three to five hours per day for a morning and evening edition paper to twelve hours a day for a one-edition paper. In one particular case a crew was recalled on Sunday to print a special edition on the Cuban crisis, and this was accomplished in four hours from the time of the decision to recall the crew till the first paper was printed. With precomposed material, this could have been reduced an hour.

If the plates had not been prepared in advance and no crew was on duty, up to eight hours could be required to produce and distribute a special civil defense edition. Smaller cities have a less severe distribution problem, and could in many cases require less time.

Since distribution could be a large fraction of total time involved, depending upon what time of day distribution was attempted, alternative distribution schemes might be considered. Possibilities are:

1. Wholesale distribution from aircraft over high population density areas
2. Use of U. S. Post Office trucks and mail carriers on special call
3. Wholesale distribution from police and fire department vehicles, etc.
4. Distribute to supermarkets, etc. and announce availability over radio, TV.

<u>Costs</u>

The costs of crash information dissemination measures considered here are of course non-attack dollar costs. There would be little legacy value for any of these measures, except that the newspaper editions might be retained for some time. It is also likely that the general level of knowledge concerning weapons effects would be increased; this is a goal on which a great deal is spent in non-crisis times.

The total manpower involved is relatively small and since this measure must be carried out early in the crash period, there would be little competition for the manpower used. Relatively few of the crash measures do not involve large scale public action; this is an unavoidable aspect of rapid mobilization. The maximum dollar cost of 100 million copies of newspapers would be two million dollars in a non-attacked economy. The cost of pre-positioned tapes for radio and TV stations (less than $50 each) is negligible. The major non-attack dollar cost would be loss of advertising revenue. The average daily expenditures for advertising in 1960 was about $10 million for newspapers, $2 million for radio and $4.5 million for TV.

Conclusions

Since actions which can be implemented within one day to two weeks involve mobilization of large blocks of the population, a crash information dissemination plan utilizing all available resources is an essential aspect of all crash planning. Further, these measures are generally non-competitive with the other crash measures, and hence are universally recommended as an element of federal, state and local crash planning. It is assumed that the population is highly motivated during the kind of crisis that would prompt crash civil defense action. The specific goals to be achieved are rapid public instruction in the fundamentals of nuclear weapons effects and the nature of the fallout threat, and the dissemination of the specific instructions concerning actions that can most profitably be taken in each locality.

It is recommended that if the concept of extensive crash civil defense planning is accepted by policy makers, a crash public information plan be written to allow effective implementation. Further, the national TV networks are best suited to rapidly disseminate general technical information concerning weapons effects and general principles of fallout protection. The local radio stations can also carry information of local importance as well as announcements by local officials. Radio and TV quick reaction capabilities allow them to operate while newspapers are being prepared for distribution. Newspapers should be reserved for substantive information concerning the crash measures recommended for a particular area covered by the distribution of the papers. Papers are better suited to the detailed instruction for the improvisation of shelters, survival techniques, preparing for thermal and blast effects, maps for optimum evacuation, etc., since they can be retained for future reference, are less subject to misinterpretation, and can instruct more effectively.

Chapter 6

EVALUATING CRASH MEASURES

Throughout the previous chapters, references have been made to the necessity of planning the use of time available for crash civil defense measures. However, planning must not only include the establishment of procedures for specific activities, but the establishment of some priorities for these activities and sequences in which they will be performed. In order to accomplish this, there must be some way of making comparative evaluations. Some possible procedures and principles for such evaluation will be noted here.

First, it is desirable to establish a matrix or framework in which the evaluation is to be made. This will involve defining the measures or combinations of measures under consideration, and the determinants against which they must be compared. Such an evaluation will have to be conducted for each area that a crash plan is written for.

The major determinants in this case are the possible attack conditions and the natural environment. Attack conditions may vary not only by type, but by time of attack. All possible conditions of attack cannot be considered. Therefore, representative conditions will need to be used. At least for early stages of planning, the following broad categories may be adequate:

Type of attack: Counterforce with no direct attack of population centers
Limited scale countervalue attack of population centers
Full scale countervalue attack of population centers.

Times of attack: 1, 7 and 14 days after beginning of crash civil defense activity.

The natural environment may also vary widely, but can be represented by general types of weather conditions, such as winter and summer.

Definition of the crash civil defense measures may be done first with respect to individual activities, such as the improvement of existing downtown shelters. However, ultimately in the evaluation procedure it will be necessary to consider combinations of activities and the sequence in which they are performed. The reason for this is that the value of many activities will depend upon whether or not other activities were performed. For example, evacuation plus improvisation of shelter in the reception area is in many cases of greater value than the sum of the values of the independent activities.

Determination of Values and Costs of Measures

Once a matrix has been established, values and costs must be assigned for each possible activity for each of the general attack and natural environments selected. Those familiar with military operational planning will recognize this process as similar to the commander's estimate of the situation, in which he compares his opponent's and his own possible courses of action. Like the military commander, the civilian defense decision maker will usually only be able to make qualitative comparisons.

The value of actions taken may be in terms of lives and resources saved that would otherwise have been lost due to the direct effects of the attack - immediate weapons effects and fallout. These will vary widely according to the type of attack, and gross comparisons are possible. For example, a hasty evacuation of a city has a large value when a full-scale countervalue attack is the situation. On the other hand, the same action in the case of an attack limited to counterforce targets may even have a negative value, since the population may be moving to less effective shelter.

The costs of crash civil defense measures will be difficult to estimate. In general, they will be in terms of lives lost for reasons other than direct weapons effects and fallout, resources lost or used in implementing the action, resources used in sustaining the action and personal sacrifices. If the attack comes, the costs incurred are insignificant compared to the costs of the attack; most of the resources used would be destroyed anyway. Hence, if one assumes an attack is certain, cost-effectiveness measures are not applicable since everything that can be expended will be.

It should be evident that it is difficult, if not impossible, to estimate these costs and relate them to a common base for the calculation of an overall cost. Numbers of lives lost due to accident, starvation, freezing, or disease occurring as the result of a crash measure would be dependent not only on specific environmental conditions, but upon individual attitudes and actions that cannot be taken into account. Even dollar costs for resources used are relatively meaningless. Relating lives lost or shortened and resources lost in some common term would call for the definition of many restraints upon which it would be impossible to get agreement.

It is not feasible for the Government to "spend" a large sum within fourteen days. Many of the expenditures would be voluntary, and by individuals aware of the crisis implications themselves. Consequently, costs of crash civil defense actions can only be determined qualitatively. In such comparisons, decisions are further complicated by the fact that there may be actions taken when there is no subsequent attack. In this case, some recognition must be made of the possibility that the action may have a "legacy" value - that is, the action would have some future utility against which at least part of its present cost may be charged. Examples would be the improvement of shelters that are likely to be used at another time or the training in carrying out certain procedures that would be of value in some future performance of the activity.

In general, however, the decision maker can array his actions in such a way that those with a low cost will be taken early, and more costly actions taken as the tension and probability of imminent attack increases. Figure 2 shows how typical crash civil defense measures may be sequenced so that their order of implementation will be compatible with their costs.

Determination of Payoffs

A usual method of determining payoffs is to take the ratio of values to costs. But this requires relating both of these factors to some common base, such as dollars, and we have already noted that this is difficult, if not impossible. Even if we could do so, this type of cost effectiveness measure may not be important. For instance, some measures with little or no cost could be shown to have an extremely high cost effectiveness because of the fact that it promised to save some lives under some situations. But the lives in question, plus many times their number, could be saved by a more costly measure.

This does not mean that a measure with high cost effectiveness, if such can be determined, should not be used, but that cost effectiveness may not be the best measure, or even a good one, of determining what crash civil defense measures should be undertaken.

Until better techniques have been developed, the decision maker will probably be faced with a choice of alternate plans with no better indications of effectiveness than the following:

Figure 2

General Crash Strategies

Activity

Level of Crisis →

11. Enter shelter
10. General alert for tactical warning
9. Controlled distribution of all resources
8. Shut down essential industries
7. Control of food and essentials
6. Improve and improvise fallout shelter
5. Directional signs to shelter
4. Crash public information program
3. Position equipment for shelter improvisation
2. Stock all shelters with non-federal supplies
1. Accelerate existing programs

A General Crash Strategy for Low Probability Target Areas

Activity

Level of Crisis →

12. Enter shelter
11. Complete evacuation
10. Resource protection (if shelter has been provided)
9. Shut down essential industry
8. As evacuation warrants, move federal shelter stocks
7. Control food and essentials
6. Crash public information program
5. Begin evacuation at rate to fill shelters
4. Improvise and stock shelter outside area
3. Move non-federal food outside area
2. Position earth-moving equipment
1. Accelerate appropriate existing programs

A General Crash Strategy for High Probability Target Areas, High Population Density, Mild Weather Conditions.

Alternative A

Payoff for some attack conditions - High

Payoff for other attack conditions - Low or Negative Value

Cost for all attack condition - High

Cost for no-attack conditions - Moderate

Alternative B

Payoff for all attack conditions - Moderate or Low

Cost for all attack conditions - Moderate

Cost for no attack - Moderate

Though such alternatives may not seem worth the trouble of detailing and analyzing, if the planner does nothing, he will automatically have chosen the third alternative where the cost is nothing, and the payoff is nothing, regardless of the attack conditions.

Summary

To summarize the principles that have been brought out in the preceding paragraphs:

1. Crash civil defense plans must be evaluated in a matrix containing representative types and times of possible attack.
2. Combinations of sequential measures as well as isolated measures must be considered.
3. Values of measures will vary widely depending upon the type of attack; costs will vary principally according to the time of attack and must be considered in the case where attack does not occur.
4. The identification of measures for determining payoff will be

extremely difficult. However, systematic analysis can result in gross comparisons of effectiveness which can be used as a basis for decision making.

Two complementary approaches to more quantitative evaluation of crash civil defense measures are possible:

1. Analysis of the effects of crash civil defense measures (increased protection factors, dispersal) using a Jumbo NREC damage assessment under varying attack conditions.
2. Detailed analysis of one or more geographical localities in which gross effects of crash civil defense measures can be calculated.

Chapter 7

CRASH PLANNING

There are several inherent constraints placed on the kinds of activities that can be considered by the crash planner. No extensive prepositioning or construction of special purpose equipment can take place before actual implementation of the plan. Implementation can be initiated only by top level decision makers at times of crisis. The activities to be conducted during the planning phase will be the preparation of detailed planning documents, evacuation maps and prepositioned newspaper plates and radio and TV tapes. Only non-military resources will be available during military crises. Another essential constraint is that crash CD planning be compatible with existing civil defense plans. It should be pointed out, however, that contingency plans which assume tactical warning may differ considerably from those which assume strategic warning. Crash plans will include a specific set of reactions to the tactical warning, and in fact should improve the reaction to tactical warning. Finally, since crash plans are held in abeyance until the crisis (they may in fact be classified), there can be no specialized training of the general public for crash activities; the plans must depend only on existing skills for implementation.

The specific survival activities will generally be under the direct supervision of the local leaders. Since the activities themselves are specific to the area, this must be reflected by strong local and state participation in writing the plans. But the federal and regional CD offices will also have essential roles in crash planning. First, research and documentation of the concepts and methods involved in crash planning must be provided and distributed. It is likely that the decision to implement crash plans will rest with the President. If a national emergency is declared under Public Law 920, his decision to implement crash measures would become more than a suggestion for state officials.

The previous chapter was concerned with the problem of constructing the optimum mix of crash measures. We shall discuss here some of the parameters which affect major planning strategies as well as the individual measures.

Geographic Areas

The major effects non-targeted areas will suffer are possible fallout and deprivation of resources that targeted areas have normally been supplying. A crash plan for areas which have a low probability of being targets is relatively simple to construct. All available effort can be directed towards these threats and once adequate provisions and protection have been provided, these areas might aid less fortunate ones.

The remaining possible target areas have a much more severe problem, and must generally design their strategy with many other contingencies to face. In large part, this chapter is addressed to these areas, although this should not be taken to imply that the non-target areas cannot profit from crash planning; generally, they will profit the most, since a few days of effort can essentially guarantee their survival.

As we have pointed out previously, the success of many of the crash measures depends strongly upon the terrain, transportation resources, food supplies, population distributions, and other parameters peculiar to the geographic area. These must be taken into account during planning. When analyzing measures, we have pointed out how these parameters affect implementation.

Seasonal or Climatic Limitations

The major strategies of population dispersal and shelter improvisation must be strongly dependent on the climate. In areas with severe seasonal variations, it will be desirable to have two contingency plans, one for cold and one for warm weather. The more temperate climates have a simpler problem. In many cases, the warmer climates have few existing shelters, hence they lose little fallout shelter by evacuation. Also, there are fewer basements in the South to offer protection. Since populations can survive without much clothing or heat in these areas, a combined strategy of evacuation and shelter improvisation for these target areas is desirable.

Although the severity of the crisis which prompts crash actions gives some indication of the time before the expected attack, in most cases, time will be the greatest uncertainty of all. It will be necessary that overall direction for the crash effort be provided by top level decision makers who will take into account the severity of the crisis. However, the uncertainty will make the quickly implemented measures which yield moderate to high payoffs desirable initially. Once a low level of protection has been offered (after evacuation, if this is part of the plan), then the more extensive measures can begin. Since multiple plans are more difficult to construct, it appears desirable to construct a single plan which can be implemented in "series;" allowing the activity to match the level of crisis.

Intensity and Nature of Attack Expected

It is possible that either due to espionage or negotiations, top level decision makers will have some knowledge of the most probable type of attack.

Attacks could range from counterforce to countervalue and they could be staged over varying time periods if the enemy has secure weapons. If it is felt such knowledge is certain enough to affect planning, then the decision maker should have sufficient flexibility to incorporate this knowledge into plans.

Dollar Costs of Implementation

In most cases, it will not be certain that an attack will actually materialize after the crash plan has been implemented. As the crisis intensifies, the probability of attack increases. The dollar cost is of primary interest in making the decision to implement, since this will be essentially a net loss if no attack occurs; i.e., the preparations have little legacy value. For this reason, the decision maker will prefer a plan which calls for increasingly "costly" measures as the intensity of the crisis increases. While reasonably accurate non-attack dollar costs can be estimated for implementation of the measures, it is difficult to relate this to the degree of risk associated with the situation. As might be expected, the most effective measures are generally the most costly.

Effects on Potential Attackers

It has been argued that any civil defense activity is provocative, and that a crash program would be particularly provocative at a crucial time. While we have not considered the problem in this study, it appears that under most circumstances the political and military activities which will precede overshadows a crash CD effort, and hence this would be a second order effect.

Population Mobilization

Another aspect of the decision problem is whether the population should be alerted and mobilized. Here again, the initial phases of the plan should consist of activities that can be accomplished without mobilization of the entire population. In particular, this would include activities that the CD and other federal, state and local agencies can carry out themselves. Again, the more effective measures require mass population mobilization, and hence they must be reserved until the crisis is sufficiently severe to justify the "cost" of mass activity.

Finally, in this chapter we shall include a possible distribution of crash planning activities among the levels of government.

Federal activities

1. Documentation of crash concepts and planning techniques
2. Research in effectiveness of measures
3. Special crash public information programs
4. Decision to implement plan (Public Law 920)
5. Make major strategy decisions for crash activities (i.e., evacuation vs. urban shelter improvement, etc.)
6. Maximum acceleration of appropriate federal programs.

State activities

1. Coordinate evacuations
2. Direct food and resources distribution to evacuees
3. Develop industrial evacuation and hardening crash plans.

Local activities

1. Evacuation plans, marking streets, traffic control
2. Specific shelter improvement plans for buildings
3. Survey shelter improvisation sites, locate earth moving equipment, etc.
4. Public information program for specific area instructions (evacuation maps, shelter distribution maps, instructions for measures).

CONCLUSIONS AND RECOMMENDATIONS

This study has indicated that the effectiveness of present and future civil defense programs can be significantly increased by the addition of crash planning. A quantitative estimate of improvement depends on the kind of attack assumed as well as the kind of program in existence at the time of implementation. Low probability target areas could essentially guarantee survival against fallout and the immediate effects of resource deprivation with one week of crash activity. High probability target areas could add significantly to their survival potential by a properly combined strategy of evacuation and shelter improvisation. It is estimated that a one week crash shelter program alone could reduce casualties by at least thirty million. The major liability of implementing crash plans is the costs incurred if the attack should not materialize.

The following recommendations are made on the basis of this as well as other studies. Those studies which have influenced the conclusions and recommendations were referenced at the point they entered the argument.

In general, efforts should be continued which will lead to the incorporation of operational crash plans into existing civil defense plans and programs. The cost of crash planning is within the present civil defense budget constraints, while the cost of long range programs of comparable effectiveness is not. The President should be offered crash civil defense measures as a decision option during intense international crises.

In order to implement the general recommendation, the following actions seem most appropriate at this time:

1. Write a detailed crash plan for several different geographic areas. This exercise will give insights into the problems to be encountered

in large scale operational crash planning, as well as allowing a specific assessment of survival improvement. This document provides sufficient data to construct such pilot plans.

2. Prepare and distribute an OCD document introducing the concept of utilizing strategic warning through crash planning to all civil defense personnel.

3. Introduce the concept of crash activities to the general population through existing public information programs. Crash planning should be presented as a part of existing civil defense programs which will provide specific instructions for action during the intense crisis which may precede a nuclear attack.

4. Prepare a crash public information plan for national dissemination such as the one outlined in Chapter 5 (to be released only during the crisis). The program could contain only general information on weapons effects, the nature of fallout, protective construction principles, etc.

5. Continue basic research in effectiveness studies of crash civil defense measures, incorporating recent research results into the evaluation of crash plans.

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Appendix A

SEVERAL CRISIS TENSION SCENARIOS

In this appendix, several crisis - tension scenarios are outlined. The major reason for presenting these scenarios is to demonstrate the plausibility of political-military situations in which a crash plan would be implemented were it available. The last section of the appendix presents a generalized scenario, or "escalation ladder" from reference 1. The first three scenarios can be tied to the various "rungs" of this escalation ladder.

SCENARIO A

Time from Initial Incident		Incident
Days	Hours	
0	0	Ground attack by Soviet forces in Europe
0	6	U. S. use of tactical nuclear weapons against Soviet force
0	8	Soviet uses tactical nuclear weapons
0	12	* U. S. threatens to use strategic weapons on Soviet if ground forces are not recalled
0	15	Soviet Union halts ground attacks in Europe; announces it will settle for only "limited concessions" in Europe
2	12	Negotiations begin: Russia continues to hold gains in W. Germany. President warns people in U. S. to be ready for "any eventuality"
6	0	Soviet insists on demilitarization of W. Berlin and W. Germany as terms for troop withdrawal; threatens to destroy U. S. if it uses nuclear weapons
6	16	U. S. rejects Soviet conditions; appeals to Soviet not to cause catastrophe
6	18	Soviet appeals to "neutral" bloc on basis that it is only trying to "insure permanent peace" by disarmament of W. Germany
6	20	Neutrals appeal to both sides to settle differences without "rash" actions
7	12	Negotiations renewed at urging of neutrals
10	18	Soviet ground forces renew advance with use of tactical nuclear weapons against NATO troops and nuclear strikes against missile sites in W. Europe; USSR announces that it will forcibly demilitarize W. Germany
10	21	NATO and Polaris missiles strike Soviet strategic targets
10	23	Soviet Union attacks U. S. cities; announces that it has "many" more weapons for U. S. cities if U. S. continues its course of action.

* Initiation of crash civil defense measures. Time for crash civil defense activities: 9 days and 11 hours.

SCENARIO B

Time from Initial Incident		Incident
Days	Hours	
0	0	Civil War begins in Poland
1	0	Some military forces join revolt in Poland and other European satellites
6	0 - 12	NATO nations, particularly U. S., send arms to support uprising; NATO aircraft flown by volunteers engages Soviet aircraft over Poland
6	15	* Soviet issues ultimatum to NATO: Cease all evidence of aid in 24 hours, or NATO military bases will be struck by Soviet nuclear weapons
6	20	U. S. warns Soviet not to use nuclear weapons or its cities will be attacked; NATO nations unofficially continue support of revolt
7	16	Soviet missile attack on NATO sites and U. S. nuclear forces in Europe
7	18	U. S. nuclear forces attack Soviet control sites and nuclear bases
7	19	Both Soviet and U. S. launch attacks on cities, simultaneously calling for other side to cease before they are utterly destroyed.

* Initiation of crash civil defense measures. Time for crash civil defense activities: 1 day and 4 hours.

SCENARIO C

Time from Initial Incident: Days	Hours	Incident
0	0	Soviet Union sends "volunteers" to support of uprising in Turkey
1	12	U. S. STRICOM units arrive to reinforce Turkish government forces
2	6	Major Soviet forces enter Turkey to oppose U. S. "agression"
2	15	* U. S. issues ultimatum to Soviet Union to withdraw all forces within 72 hours or its military bases will be attacked with nuclear weapons
2	23	Soviet asks U. N. to call emergency session to consider U. S. threat to world peace
4	0 - 12	U. N. Security Council meets, but agreement is impossible; U. S. repeats ultimatum
4	18	Soviet halts movement of forces into Turkey and asks U. S. to withdraw its ultimatum while further discussions are held
4	20	U. S. Government agrees to "consider withdrawal of ultimatum" if the Soviet Union will take immediate steps to draw back its forces
5	5	Soviet launches attack on major U.S. cities, saying it cannot wait to be attacked. It warns that it will destroy all of U. S. if retaliation occurs.

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* Initiation of crash civil defense measures. Time for crash civil defense activities: 2 days and 14 hours.

THE RELATION BETWEEN CIVIL DEFENSE TACTICS AND
A GENERALIZED SCENARIO OR "ESCALATION LADDER"

(Reference 1)

Aftermaths

	25.	Some Other Kind of General War	
	24.	Limited Strategic Attacks on Population	
Central War Rungs	23.	Counterforce-plus-Avoidance Attack	Desperate
	22.	A Partial Disarming Attack	
	21.	Formal Declaration of War	
	20.	Complete Evacuation (95%)	Crisis
	19.	Limited Strategic Attacks Against Property	
	18.	Low-Level Strategic Counterforce Attack	
	17.	Evacuation (70%)	
Bizarre (or Transition) Rungs	16.	Maneuvers Which Seriously Degrade Enemy's Defenses	
	15.	Alegal or "Justifiable" Counterforce Attacks	Emergency
	14.	Limited (Tactical) Nuclear War	
	13.	Spectacular Show of Force	
	12.	Super-ready Status	
	11.	Limited Evacuation (20%)	Wartime Mobilization
	10.	Intense Crisis	
	9.	Conventional War	
Traditional Rungs	8.	Limited Military Confrontations	Peacetime Mobilization
	7.	Harassing Acts of Violence	
	6.	"Legal" Harassment	Accelerated
	5.	Model Mobilization	
	4.	Show of Force	
	3.	Political, Diplomatic, and Economic Gestures	Normal
	2.	Transition of Real Crisis	
	1.	Ostensible Crisis	

Subcrisis Disagreement

1. William M. Brown, <u>Strategic and Tactical Aspects of Civil Defense with Special Emphasis on Crisis Situation</u>. Report HI-160-RR. New York: Hudson Research Institute, 7 January 1963.

Appendix B

THE USE OF TRENCHES IN A CRASH SHELTER PROGRAM

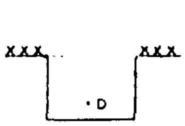
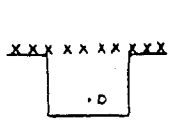
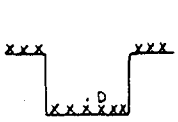
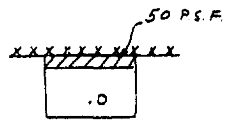
If one is faced with a field of radioactive fallout, with no building materials or existing structures to provide protection, a simple hole in the ground will give a protection factor significantly greater than unity. However, this protection factor depends strongly on the dimensions, type of cover, lip and ridge shape and both macroscopic and microscopic terrain features. In the following, we shall examine the sensitivity of the protection factor to each of these parameters separately, and finally the results will be incorporated into a list of construction recommendations.

Covers

The addition of a cover, even if completely transparent to gamma radiation, will significantly improve the protection factor of a trench shelter. In Table B-1 the contributions due to skyshine, lip penetration, and fallout in the trench if no cover is present, are calculated for a basic nine feet by nine feet square foxhole type shelter which is six feet deep with the detector two feet from the bottom of the shelter. The calculations and notation used are based on Reference 1. D/Do is the ratio of the detector response at D to a detector placed three feet above an infinite contaminated plane.

Table B-1

P.F.'s For Several Basic Foxhole Configurations

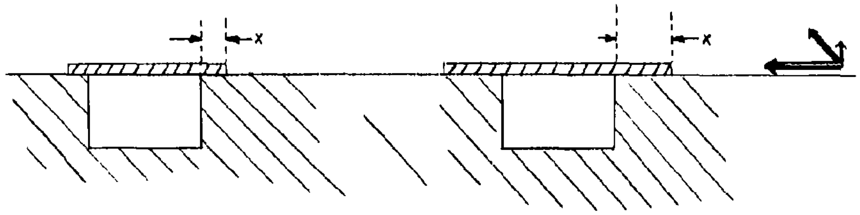
	a	b	c	d
				
1. D/Do, Skyshine	.018	.018	.018	
2. D/Do, Lip	.012	.012	.012	.0025
3. D/Do, Other		.077	.140	.035
4. P.F.	33	9	6	26

If a transparent cover is provided, the calculations for Table B-1-b are applicable. However, it should be possible to largely decontaminate the cover either during or shortly after all the fallout has arrived. This could be accomplished by either shaking the plastic or cloth cover, or completely removing it after all fallout has arrived. The type of transparent cover is immaterial as long as it does not admit the fallout particles into the shelter. Thin plastic such as polyethylene or mylar would be adequate, especially if backed with sheets or blankets to lend strength. A tent would be adequate if available, and if the foxhole is a one man shelter an umbrella would suffice since it could be shaken frequently to remove fallout. A highly satisfactory transparent cover could be made from sheets, tablecloths, or blankets pinned or sewn together quickly and then painted with any available household paint. (A light color would be preferable since it would reflect thermal radiation more readily.) A transparent cover should be supported in the center with a pole of some sort so that it can be shaken for decontamination. As can be seen from the comparison of protection factors for shelters in Table B-1, the payoff is high for at least providing a transparent cover for the shelter and decontaminating it as soon as possible. This sort of cover requires no materials which could not be obtained from household stock.

A more substantial dense material cover could be improvised with additional time and materials should they be available. If trees are available and saws or axes to cut them, a timber and earth cover could be built. It has been suggested that in some cases concrete slabs from highways might be removed and used for coverings. Reference (2) suggests as one expedient the use of an auto, floor covered with earth, as a covering. However, great care must be exercised with such covers so that the scattered radiation from the strong horizontal component does not increase the radiation in the shelter above that already present from skyshine. Of course, the dense material cover which is flush with the surface of the fallout field (Table B-1-d) is most desirable for this reason, but it is most difficult to improvise without internal supports. A critical dimension when constructing a cover is the distance x in Figure B-1. In the figure, the arrows represent the relative strengths of the components of the radiation in the directions indicated, for a contaminated plane. In fact, the horizontal radiation component is over one hundred times the downward component for an infinite plane of contamination (Reference (1)) with a perfectly smooth surface. This effect is reduced as the surface becomes rougher. In general, the distance between the lip of the hole and the edge of the protruding cover should be several times the thickness of the cover, unless the local terrain is very rough or a proper ridge has been constructed.

Figure B-1

The Above-Grade Dense Cover



Dimensional Effects

The actual dimensions and shape of the trench shelter must depend upon the equipment available for construction (hand shovels to steam shovels), the condition of the soil, the weather, time available for construction and the level of the water table. Bulldozers would probably have a minimum blade width of nine feet, trenchers would be less, while hand shovels would not impose a minimum width. How sharp the lips can be made depends largely upon the type of soil. Of course the maximum depth will be approximately the ground water table. In several cases, the choice of terrain can modify these factors, and part of a crash plan for a specific locality should be a ground survey in peripheral areas to determine optimum trench construction sites.

The dimensions of the hole seriously affect the PF. For a given floor area, the deeper the shelter the higher the PF. Also, as the solid angle subtended by the hole at the detector approaches 0, the lip contribution approaches the total response. In Table B-2, the PF's for several foxhole type shelters of varying sizes have been computed to give an indication of the effect of these parameters in practical shelter sizes. In all cases a configuration similar to Table B-1-a is assumed, i.e., a decontaminated transparent cover is provided.

Table B-2

PF's of Various Shelters, Detector 2' From Bottom

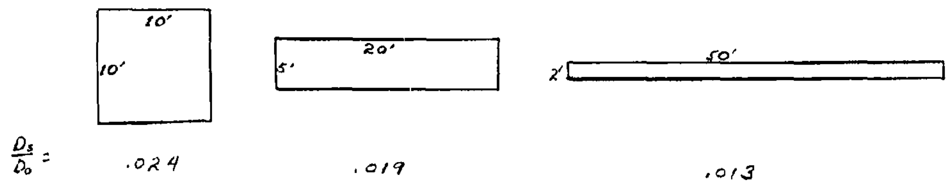
Size \ depth	3'	6'	9'	12'
3' dia. circle	14	145	550	800
6' x 6' square	12	42	125	300
9' x 9' square	12	33	71	135
12' x 12' square	11	26	49	88

It can be seen that the ratio of the aperture area to depth should be kept as small as possible. It would be desirable to continue deepening the shelter after occupancy if the water table permits. If long trenches were dug, autos might be driven directly into the trench. Since the depth is severely limited by many practical considerations, great care must be taken to see that the aperture size is kept relatively small.

Another dimensional effect which should be considered is the elongation of the aperture of the foxhole. Since a certain minimum area is required for a family group, and there is generally a practical limit to the depth of a trench, the shape of the aperture is the only dimensional parameter left for variation. In Figure B-2, the skyshine contributions, Ds/Do, are recorded for various shapes of holes which have constant floor area (100 ft^2) and constant depth (6 ft deep) with the detector two feet from the floor.

Figure B-2

Dimensional Effects on Skyshine Contribution



Assuming the lip contribution decreases in approximately the same way, it can be surmised that the PF's computed in Table B-2 can be increased by twenty-five per cent with maximum practical elongation of a family sized shelter.

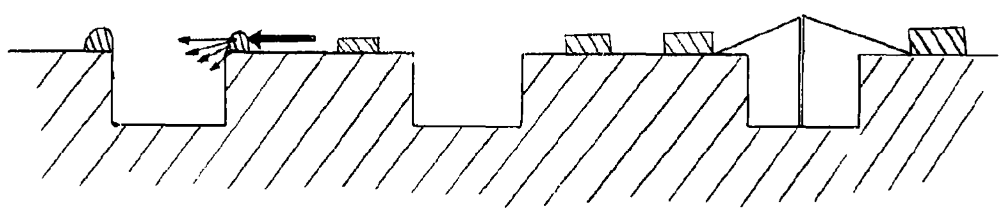
Lip and Ridge Effects

One of the greatest dangers of trench shelters is the inadvertent construction of a thin dense material ridge close to the edge of the shelter which protrudes above the fallout field. As was discussed previously, the strongest component of radiation is horizontal to the field surface, especially on smooth terrain. When this intense radiation hits such a ridge (Figure B-3-a) it is scattered in all directions as well as being partially attenuated. Since the intensity of the horizontal beam can be hundreds of times greater than the skyshine, the radiation which would be scattered into the hole could easily exceed the skyshine contribution. To help this situation, a lower, thicker ridge should be constructed away from the edge of the hole, as in Figure B-3-b. In general, the ratio of the height of the ridge to its distance from the lip should be as small as practically possible.

The lip effect is simply the contribution due to the radiation in the immediate vicinity of the hole which gets through the lip of the shelter. While the fractional contribution due to a contaminated lip increases as the aperture size gets smaller, for practical shelter sizes the lip contribution is roughly the same as the skyshine contribution. To reduce this lip contribution even further with a transparent cover, a cover configuration such as in Figure B-3-c would be desirable, since shaking the tent-like structure would deposit most of the fallout at a sufficient distance from the lip so the radiation would be largely attenuated. If this configuration is used, it is also necessary to dig a drainage slot through the ridge to allow rain water to run away from the shelter. In fact, drainage problems should be kept in mind at all times, since rain could wash quantities of fallout into a trench.

Figure B-3

Ridge and Transparent Cover Construction

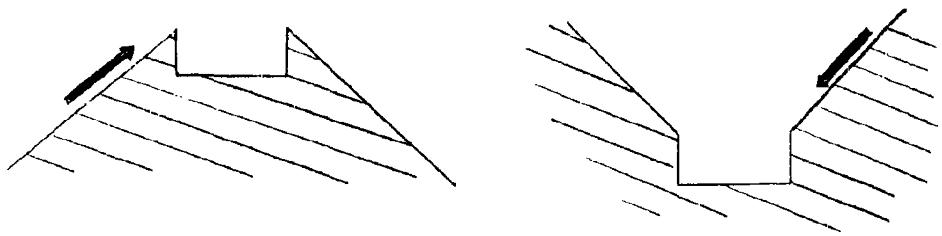


Terrain Effects

The effects of terrain, both the large and small scale features, must be considered when improvising a trench shelter. A high elevation is preferred for several reasons. Water drainage is better, making the trench more habitable as well as allowing rain to wash fallout away instead of towards the shelter. Also winds would tend to clear the higher elevations and build up deposits in valleys. Further, the large scale horizontal component of radiation would be in a more desirable direction if the trench were at a maximum elevation, as can be seen from Figure B-4.

Figure B-4

Macroscopic Terrain Effects on Trench Shelter



All of these considerations imply that higher elevations are desirable for trench shelter improvisation. As stated before, it should be a part of civil defense planning to locate the most desirable spots in the vicinity of a population center in advance of the time to implement a crash plan.

The knowledge of the effect of ground roughness, or microscopic terrain effects, is relatively limited. It is apparent that rough ground will reduce the relative strength of the horizontal component, and in fact the total intensity, since much of the radiation must now pass through earth and will be thereby attenuated. However, there is no adequate theoretical or experimental data on the extent of these effects as a function of the frequency or amplitude of the ground irregularities. Since these considerations seriously affect the PF of underground shelters, especially the poorer ones, it would be highly desirable to investigate this further. At present, an arbitrary ground roughness factor is introduced which in effect assumes the fallout is buried beneath a thin layer of earth (Reference 1). The only experimentally determined value for this factor was made with a Nevada field (Reference 3) and apparently the extremes that might occur have not been investigated. A flat plane was assumed in the previous calculations in this study. Hence, plowing or otherwise roughening the ground within a fifty foot circle about the shelter (90% of the radiation comes from this circle) would increase the calculated protection factors, possibly by a significant amount. However, since the quantitative effect of ground roughness is not known precisely, no recommendations have been made in this regard.

It is suggested that a smooth grassy surface might approach a perfectly flat plane (such as smooth concrete) since the grass would be nearly transparent to the gamma radiation, and would suspend the fallout above the high density irregularities.

Recommendations

If no structures are available which can be stocked and improved for fallout protection in the vicinity of the people to be protected (i.e., they may have been evacuated) then:

1. Select an elevated area in which to dig the basic trench.

(A proper area should have been selected in advance by the local crash civil defense planner.)

2. After digging the trench, taking care to keep (aperture area/depth) low, use excess earth (part of which might be saved for cover) to form a ridge as in Figure B-3-c. Make lips sharp.

3. If a dense material cover can be improvised, take care to keep cover overlap (see Figure B-2) large enough.

4. If no dense material cover can be improvised, use a cover transparent to gamma radiation, such as plastic, a tent, or sheets and blankets. Elevate cover at center and extend to ridge, as in Figure B-3-c.

5. If no cover is available, use clothing, plastic bags, etc., to protect against beta-burns and prepare to remove fallout as it arrives in the trench.

6. Collect materials to improvise partial body shields as described in Appendix C for use during the first eight to thirty-six hours.

REFERENCES FOR APPENDIX B

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2. Emergency Planning Research Center. Low Cost Family Shelters. Menlo Park: Stanford Research Institute, October 1961.

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Appendix C

PARTIAL BODY SHIELDING AS AN EMERGENCY FALLOUT PROTECTION DEVICE

In many existing shelter spaces, the protection factor is so low that lethal amounts of radiation could be received in a moderately heavy fallout field. To improve this protection, a dense material partial body shield, used continuously for the first 8 to 36 hours, and later to sleep in, will prove useful. It may be improvised from commonly available materials.

There are three points which suggest that such a measure would be effective:

1. Implementation is, in many cases, easier and quicker than improving existing, but inadequate shelter.
2. There is both experimental and theoretical evidence to indicate that partial body shielding of the vital organs is effective in protecting against the effects of radiation.
3. This protective device can, in many cases, be constructed while inside a shelter.

In general, this measure will be most applicable to those individuals who must seek shelter in their own home, since it is more likely that the materials required will be readily available there. However, it is precisely these people who are most likely to have inadequate protection.

Effectiveness

In analyzing the effectiveness of partial body shielding in an emergency environment, we shall assume that some structure is available for shelter which will at least prevent the ingress of large amounts of fallout particles. Hopefully, it could be improved to a PF of around 10 - 20 before the fallout started arriving.

Since the severe confinement of lying under a dense body shield prevents use of such an individual shield for extended periods, the first question to be answered is whether the benefits gained within the limited amounts of time that can be spent in protection justify the time spent in improvising such shielding. To answer this, we plot in Figure C-1 the fraction of the H+1 hour to infinity dose and the fraction of the H+1 hour to H+2 week dose versus time in hours. This graph is based on the $t^{-1.2}$ decay law, (Reference 1).

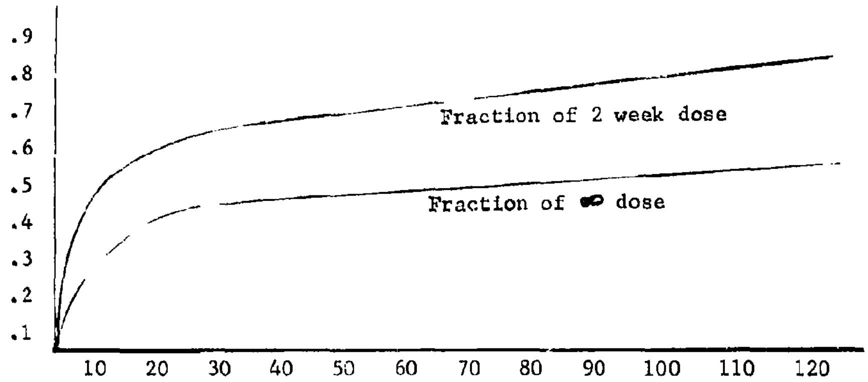
Since over 40 per cent of the two week dose is received within the first eight hours, it is clear that severe discomfort could be tolerated for this period in order to obtain this significant increase in probability of survival.

Of course, it is desirable for the shielding to cover as much of the body as possible; however, it is imperative that it cover at least the liver, spleen, intestines, and some large bone, such as part of the thigh.

While it is impossible at this time to be quantitative concerning the effectiveness of partial body shielding, experimental evidence as well as simple physiological considerations indicate that a given mass of shielding is more effective when used to cover the vital organs rather than spread over the whole body. It must be emphasized that this statement applies only to large doses of radiation, and not necessarily to small doses in which the long term effects are of primary concern.

The conclusions of (Reference 2) indicate that two benefits are to be derived from partial body shielding.

1. Shielding the vital organs alone approaches in effectiveness the shielding of the whole body in preventing lethal effects from radiation. While this was only demonstrated for certain animals, it is quite likely a similar effect exists in man.



Time (H + hours)

<u>Comparison of Radiation Dose</u>

Figure C-1

2. Since a large portion of the total dose is received within the first few hours, reducing the dose rate at this time results in a greater reduction of the accumulated or exposure dose which indicates a larger total dose can subsequently be tolerated without causing death. In other words, the maximum equivalent residual dose with shielding during the high intensity phase is drastically reduced. In particular, the assumptions made in (Reference 3) concerning the effects of prolonging the dose are as follows:

   a. Ten per cent of the radiation damage is irreparable; the remaining 90 per cent recovers at the rate of 2.5 per cent per day.

   b. Recovery after a brief exposure begins four days after the exposure.

Since the dose rate after two weeks is much lower, we are generally justified in examining the higher curve in Figure C-1 in assessing the effectiveness of expedients in removing radiation hazards in this critical two week period.

Finally, we shall include from (Reference 2) a table (Table C-1) indicating the results obtained from the partial body shielding experiments on rats who had received large doses of radiation.

Table C-1

Partial Exposure vs. Whole Body Exposure of Rats

Dose	Part of Body Irradiated	Survival (%) Partial	Survival (%) Whole Body
450	Lower half	100	40
500	Lower half	87	38
850	Lower half	90	50
1000	Lower half	0	0
500	Lower half and 1/4 upper half	96	38
600	Lower half and hemithorax	78	40
850	Lower half and hemithorax	70	50
850	Upper half	92	0
1000	Upper half	100	0
600	Upper half and 1/2 lower	67	40
500	Less head and spleen	76	38
500	Less spleen	67	17
600	Less sternum	97	50
850	Less sternum	34	0
830	Less hind legs	25	4
500	Less liver	88	38
600	Less liver	83	40
830	Less liver	63	4

Feasibility

We have seen that to be effective, the individual partial body shield must be maintained essentially uninterrupted for the first 8 - 36 hours after the arrival of fallout. The feasibility of implementing such a measure for an individual or family unit will depend upon:

1. The availability of materials to construct the shield
2. The ability to withstand the extreme confinement for this time period.

While confinement to a prone position for 36 hours would be quite unpleasant, it is felt that if the adult individual was convinced that his survival depended upon it, he could quite easily withstand the discomfort. The availability of tranquilizers might reduce the tension from such confinement. However, small children would not tolerate such confinement willingly. The situation would warrant tying their hands and feet and wrapping them tightly within a sheet for this period in order to protect them against fallout. With a small support such as could be improvised with books and doors, earth, sand, or other dense objects could then be piled over their bodies. Diapering with blankets or sheets would be advisable at any age; the only requirement for at least a 24 hour period would then be water which could be provided with small exposures to the adults providing it.

The available materials for constructing an individual shield are limited only by the ingenuity of the improviser. In Table C-3 (Reference 4) are listed the densities in lb/ft^2 of some materials generally available in a household or in other buildings.

Some possible improvised individual shields are given in Table C-2. The materials are generally available within the shelter. Non-attack dollar costs are very low for most of these shields and the time to construct any given shield would be less than one hour.

Table C-4 gives the approximate mass densities required to increase the PF to the given amounts both above and below grade. It is assumed that the "mass shell" completely surrounds the detector in these calculations; hence they only give a rough indication of effectiveness.

Table C-2

A List of Possible Individual Shielding Devices

1. Books, bricks, etc., used to support an interior door. Cover door with earth, books, plaster, etc.

2. Child's plastic wading pool filled with water and supported one foot above floor with doors, plywood, etc.

3. Washing machine supported on bricks, blocks, etc., and filled with water.

4. Small wooden support fabricated with wall panel, furniture, table top, etc., and earth moved in from outside for cover if fallout hasn't arrived.

Table C-3

Table of Mass Thicknesses

Material	Thickness (inches)	lb/ft^2
Asphalt Shingles	-	2
Brick	2	16-20
Concrete Block	8	55
Gypsum Board	1/2	2
Plaster on Lathe	1/2 - 3/4	5-6
Soil	1	6-11
Steel Plate	1	41
Wood	1	2½

Table C-4

Approximate Mass Directly Over Body Required To Increase Protection Factor by a Factor of F

	F	lb/ft^2
Below Grade Shelter	25	60
	1000	150
	6' Above Grade Shelter	
Above Grade Shelter	3	50
	30	150
	100	200

Summary Recommendations

IF: Some fallout shelter is available (Protection Factor 2-10) that will prevent ingress of fallout particles (preferably below grade).

THEN: Attempt to provide, with any dense materials available, a partial or whole body shield of 50-100 lb/ft^2, and stay in it from 8 - 36 hours after the arrival of fallout, and use it to sleep in for several weeks thereafter.

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Appendix D

EFFECTIVENESS OF THERMAL COUNTERMEASURES

To investigate the area in which thermal countermeasures would yield large payoffs, it is useful to derive the ratio between the area damaged by blast and the area which would receive sufficient thermal radiation to ignite many fires.

From (Reference 1) we have an expression for the thermal radiation intensity, Q, (in cal/cm^2) as a function of R_t, the range in miles from the explosion, W, the yield in kilotons, and T, the transmittance of the atmosphere. An air burst is assumed most probable against large countervalue targets. This expression is

$$Q = 1.04WT/R_t^{\,2}$$

Hence, we can immediately write the ratio between A_t, the area which receives Q or more cal/cm^2 of thermal radiation, and A_b, the area which receives an over-pressure of b or more psi, where R_b is the radius for b psi peak overpressure. This is:

$$A_t/A_b = 1.04WT/QR^2_{\,b}$$

But we can also write R_b as a function of the yield W (for a particular "scaled" burst height). In particular,

$$R_b = R_o W^{1/3}$$

where R_o is the b psi line for a one KT explosion. Hence we have

$$A_t/A_b = (1.04/QR_o^{\,2}). \quad T.W^{1/3}$$

At b = 3 psi, extensive blast damage will be suffered by residential units, and at Q=15, multiple fires would start. If we assume a moderately clear day, i.e., T=.5, then we find for a 1 MT air burst, A_t/A_b=1; however, if the yield of the weapon is 100 MT, this ratio becomes 6.2. This result indicates that for high yield weapons, the payoff for protecting against thermal effects is high, while for the low yield weapon, a great deal that would be saved from fire would be destroyed by blast anyway. However, even if moderate blast damage was incurred, any survivors who had fallout protection in the basements, etc., would be in great jeopardy from the burning dwelling (Reference 2). Hence, moderate payoffs are received even for low yield weapons. In most parts of the country, the probability of encountering a T of .5 or greater is high enough to warrant neglecting the possibility that one will be protected by a particularly foggy or rainy day.

Feasibility

In the typical household, some materials will generally be available for covering windows against thermal radiation. One half roll of aluminum foil would cover about 25 ft^2 and would provide very effective covering for 1 to 2 windows (those most likely to face the blast). Sufficient quantities of either light colored paint, Bon Ami, or whiting would be available in most households to cover windows. Aluminum screens attenuate from 30 - 50% of the thermal radiation and hence screens should be closed or installed.

The amount of water per square foot required to dissipate 25 cal/cm^2 of thermal radiation can quickly be calculated from the heat of vaporization of water (580 cal/gm). Allowing 90% losses due to absorption or spillage, one gallon of water is sufficient to wet 10 ft^2 of material so that it can withstand 25 cal/cm^2 of direct thermal radiation (i.e., the radiation is normal to the material surface at all points). Since the average daily water consumption per service (Reference 3) is about 700 gallons, it is apparent that the wetting of interior flammables (piled up curtains, furniture, etc.) is feasible in most cases when used in conjunction with the other measures.

Effectiveness

Effectiveness of implementing these measures will be examined from two points of view. First, we will ask whether a typical dwelling can be prepared within a few hours to withstand 25 cal/cm^2 of thermal radiation from a high yield weapon without igniting and burning. Next, we will examine the effectiveness of large scale implementation of these measures in preventing mass fires which result from isolated thermal ignitions spreading over large areas. The possibility of fires created in the blast area spreading outside to undamaged areas is of course a danger, but is much more difficult to cope with.

From Table D-1, taken from (Reference 4), it is apparent that most of the window coverings considered attenuate the radiation so that the radiation received within the dwelling will not cause ignition, especially if the flammable materials are piled up in one place and dampened with water.

Table D-1

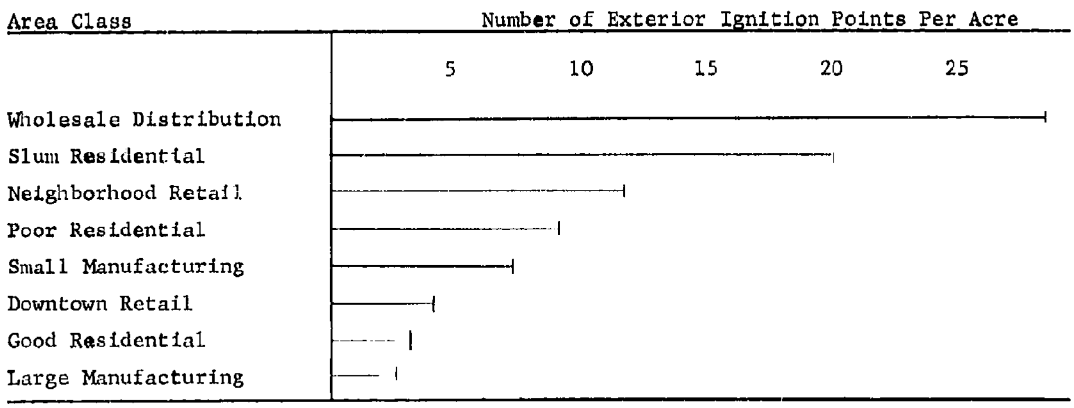
Reduction in Thermal Effects by Common Materials

Materal	Percent Reduction
Window glass	0
Aluminum shade (including screen)	70
Aluminum venetian blind (slats closed, supporting tapes protected)	98
Aluminum venetian blind (slats at 45°)	30
Aluminum insect screen, 24 x 24 and 20 x 20 mesh	50
Aluminum insect screen, 14 x 18 mesh	35
Coating on glass - Bon Ami	50
Whiting	90
Opaque paint	35

From Table D-2, taken from (Reference 5), it appears that the removal of all dangerous exterior ignition points can be accomplished within a short time since they are relatively few in number. In summary, most dwelling units with the exception of the old, highly flammable slum residential areas, can be prepared to withstand 25 cal/cm^2 within 1 - 3 hours using only materials generally available in the household.

Table D-2

Ignition Points by Type of Area



In assessing the effectiveness of implementing these measures in preventing the spread of mass fires, we use the parametric fire spread model developed in the following. In general, the advisability of implementing these measures depends upon whether the probability that an area will be consumed by fires can be reduced significantly. An effective parameter to measure fire vulnerability is the average or expected area that will be consumed if one building ignites. If, because of the physical conditions prevailing in the area, this expected area of burn is "small" then large payoffs can be expected from reducing the number of ignition points. On the other hand, if one ignition will spread over a significant area, then reducing the ignition points will yield little payoff unless nearly all were removed, which is generally infeasible.

Since we are interested not in a particular city, but only in the relative effectiveness of reducing ignition points, the model chosen assumes a regular square lattice of buildings, each of the same area and separated by the same distance. A wind is assumed which spreads the fire predominantly in one direction; the probability that fire will spread to its nearest neighbor is p. Figure D-1 describes the model.

We assume a fire is started at the origin of the coordinate system in Figure D-1. The probability that fire will spread to the nearest neighbor is assumed to be p if: (1). The direction of spread makes an angle of less than 90 degrees with the wind direction;and (2) The distance to the neighbor is less than or equal to s, where s is the unit dimension of the lattice. All other probabilities are assumed to be 0. This model is not concerned with time dependence, but only the area consumed by the ignition at the origin.

We first compute the probability that a fire started at the origin will consume all units up to some front F_n as drawn in Figure D-1.

P_1 = probability all units behind F_1 burn $= p \cdot p$

P_2 = probability all units behind F_2 burn $= P_1 \cdot p^2 (1-(1-p)^2)$ (1)

P_3 $= P_2 \cdot p^2 (1-(1-p)^2)^2$

hence,

$$P_n = p^{2n} \, (1-(1-p)^2)^{n(n-1)/2}. \qquad (2)$$

The quantity of interest is the expectation of n, E(n):

$$E(n) = \sum_{m=1}^{\infty} mp^{2m} (2p-p^2)^{m(m-1)/2} \qquad (3)$$

If we let

$$q = (2p-p^2)^{1/2} \quad \text{and} \quad a = 2\ln(p)/\ln(q)-1, \tag{4}$$

then we can write

$$E(n) = \sum_{m=1}^{\infty} mq^{(m^2+am)} . \tag{5}$$

This sum can be approximated by the integral

$$\approx \int_0^{\infty} xq^{(x^2+ax)}\,dx = q^{-a^2/4} \int_0^{\infty} xq^{(x+a/2)^2}\,dx. \tag{6}$$

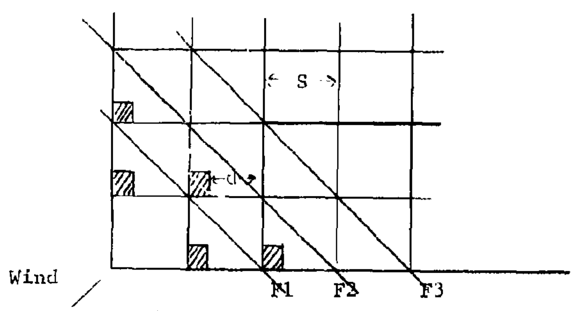
Values of interest for p are from .5 to 1.0, hence $-a^2\ln(q)/4$ is less than .01, which means the above integral can be approximated by

$$E(n) = 1/(2\ln(q)) - a\sqrt{\pi}q^{-a^2/4}/(4(-\ln(q))^{1/2}) = a^2q^{-a^2/4}/(4\ln(q)) \tag{7}$$

The area A is now defined as that area which is burned when the fire reaches the front $F_{E(n)}$, i.e., $A = E(n)^2s^2$, where s is the lattice dimension as drawn in Figure D-1.

Figure D-1

Lattice for Determining Probability of Fire Spread



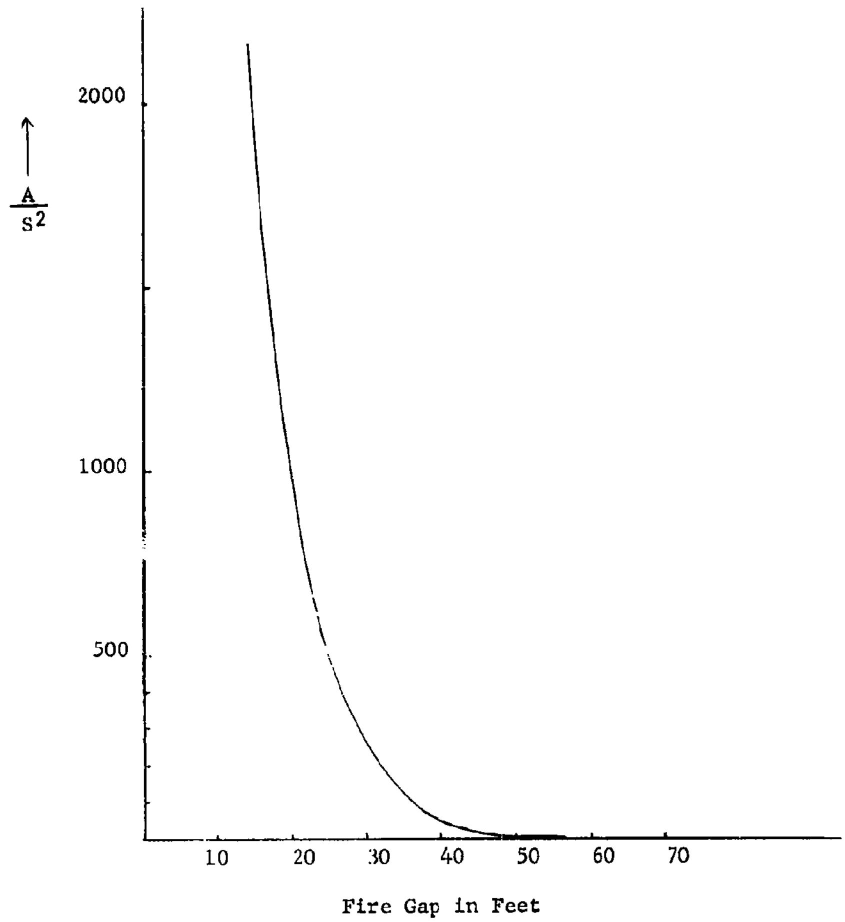
If the data on probability of fire spread as a function of fire gap, taken from (Reference 1), is used to determine p in equation (7), one can then calculate the function shown in Figure D-2, which shows A as a function of the fire gap, d, in feet. The area destroyed is in numbers of basic units; not in square feet. This figure then allows one to crudely estimate the damage to be expected from a single ignition given a particular building density.

Since the probability of fire spread data from (Reference 1) is an approximation at best (clearly probability of spread is a function of wind and building type also), the information in Figure D-2 gives only a rough indication of the effectiveness of removing ignition points.

If firefighting equipment is available, this model predicts that greater payoff is derived from preventing spread than from reducing ignition points.

Figure D-2

Area Consumed in S^2 Units vs Fire Gap



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APPENDIX E

RESIDENT POPULATIONS AND AVAILABLE SHELTER SPACES*

Urban Center	Area Resident Population	Class 4-8 Shelter Spaces	Category 4-8 Shelter Shortage
New York City (excludes N.J.)	11,389,426	16,113,700	4,724,274 (excess)
Chicago	6,794,461	6,552,476	241,985
Los Angeles	6,742,696	1,643,634	5,099,072
Philadelphia	4,650,343	2,369,809	2,280,534
Detroit	3,934,800	1,195,981	2,738,819
Baltimore	1,803,745	579,657	1,224,088
Houston	1,383,522	233,492	1,150,030
Cleveland	1,898,644	834,036	1,064,608
Washington, D. C.	1,773,712	2,213,682	439,970 (excess)
St. Louis	2,060,103	945,243	1,114,860
Milwaukee	1,436,686	505,749	930,937
San Francisco Oakland-Alemeda	2,849,249	954,789	1,894,460
Boston-E. Mass. & Rhode Island	4,273,641	1,791,421	2,482,220
Dallas - Fort Worth	1,578,701	404,545	1,174,156
New Orleans	1,035,460	327,042	718,418
Pittsburgh	2,574,775	1,132,632	1,442,143
San Antonio	687,151	120,009	567,142
San Diego	1,033,011	82,737	950,274
Seattle	1,107,213	301,589	805,624
Buffalo	1,306,967	327,359	979,598

Urban Center	Area Resident Population	Class 4-8 Shelter Spaces	Category 4-8 Shelter Shortage
Cincinnati	1,071,624	616,472	455,152
Memphis	627,019	86,307	540,712
Denver	929,383	248,202	681,181
Atlanta	1,017,188	287,488	729,700
Minneapolis - St. Paul	1,492,030	344,572	1,147,458
Indianapolis	697,567	409,068	288,499
Kansas City	1,039,493	667,700	371,793
Columbus	682,962	224,861	458,101
Phoenix	663,810	63,118	600,692
Newark and Northern N. J.	4,566,051	881,368	3,684,683
Louisville	725,140	194,583	630,557
Portland	728,088	221,795	506,293
Birmingham	634,864	82,334	552,530
Oklahoma City	511,833	232,349	279,484
Rochester	586,387	396,401	189,986
Toledo	630,647	135,021	495,626
Norfolk (Area)	803,010	174,235	628,875
Omaha	457,873	208,868	249,005
Miami	935,047	169,150	765,897
Akron	513,569	179,197	334,372
El Paso	314,070	63,126	250,944
Tampa St. Petersburg	772,453	37,935	734,518
Dayton	694,623	108,083	586,540
Tulsa	319,316	67,217	252,099
	81,728,353	44,728,972	41,273,665

* The above data obtained from Summary B National Fallout Shelter Survey, dated September, 1962.